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Application of Six Sigma Concept in Shoe Manufacturing for Quality Improvements: A Case Study

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ABSTRACT

The footwear sector plays a dominant role in the economy of Bangladesh in terms of its contribution to export and domestic market but its manufacturing process involve potential sources of defects and failures which may lead to product complaints and rejection. This study represents an application of six sigma to reduce errors and enhance quality in shoe production. Quality has been considered an essential part of any service as well as manufacturing process. The status and future growth of an organization is decides by its quality. Quality of footwear is becoming a very crucial aspect of today's most competitive time. A case study is carried out in a shoe industry, where Six Sigma method i.e. DMAIC is adopted to establish a novel approach with a view to improve quality. This process aims to understand the strategies of six sigma and its applications in shoe manufacturing.

Key words: Six Sigma, DMAIC, Footwear, Quality, Defects reduction

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INTRODUCTION

Footwear is a very potential sector of our country's growing economy and plays a significant role in terms of its contribution to export and domestic market. According to international trade report, footwear export increased by 42.33% in 2011 [1]. But its manufacturing comprises variety of processes which arise many potential sources of defects and problems like performance, aesthetic or safety nature which may lead to product complaints and rejection. These defects may cause significant financial cost through lost sales revenue or product returns [2], which insists domestic shoe making companies to inaugurate six sigma tools to face the increasingly terrific competition.

Six sigma is an effective approach for elimination of defects from any process, specifically a numerical goal of 3.4 defects per million opportunities (DPMO) [3]. The DMAIC approach is an abbreviation for the six sigma boost improvement method and it is comprised by the first letter of Define, Measure, Analyze, Improve, and Control [4].It is a very excellent approach of system control and problem-solving of manufacturing. DMAIC method successively promotes the process by identifying the key factors which are highlighted, establishing data collection methods, analyzing the causes of process failures, and dispelling variation and providing improvement plan, while monitoring and control the long-term process improvement. Stages of DMAIC form a feedback loop system where the previous stage prepares for the latter stage, and the latter stage is the deep improvement of the former stage. It was first introduced at Motorola in the 1980s and since then it has gained wide acceptance and popularity among organizations. There are about 500 enterprises have employed this methodology for instance with the objective of developing their performance [5].

There are no available literatures which can demonstrate in-depth case study showing how Six Sigma tools are carried out in shoe industry. China shoe making enterprise M corporation applies the DMAIC method to reduce the glue problem including the defect of glue, unreasonable drying time after brushing and unqualified curing[6]. T. Wang et al., used DMAIC improvement method in a traditional footwear industry with adhesive problem and found the major factors that impact the product quality problems, such as the drying time, curing tank temperature, pressure an d so on, and using the orthogonal experiment method to determine the optimal parameter combination, a practical and effective improvement scheme is obtained [6]. MAS Mia et al., worked on waste management of footwear manufacturing industry using lean sigma tools and presented a framework for the industry [7].

In this paper the authors illustrate the complete approach of six sigma application step-by-step to reduce rejection in a shoe manufacturing process through errors reduction and quality enhancement. The different stages of the DMAIC methods and the tools and techniques applied are given. The paper concludes by highlighting the key privileges and achievements from the project.

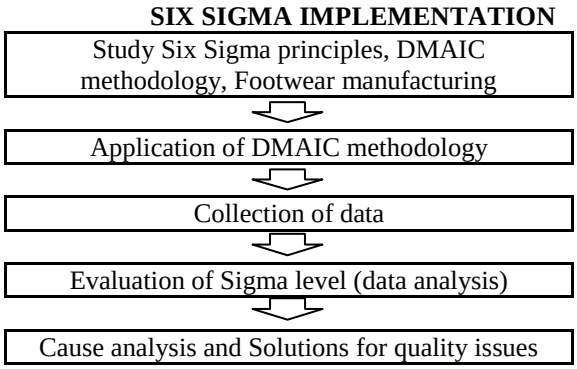

Fig. 1 Outline of Methodology

Six Sigma is an emerging approach to quality confirmation and quality management with emphasis on successive quality improvements. To attain this quality, a system must satisfy maximum 3.4 defects per million opportunities where opportunity indicates a chance for non-conformance, or not fulfilling the desired specifications. This means it needs to be nearly perfect in executing our key processes.

Manufacturing of shoe involved huge variety of processing steps from pattern development to finished product shown in fig. 2 which arise huge variety of defects.

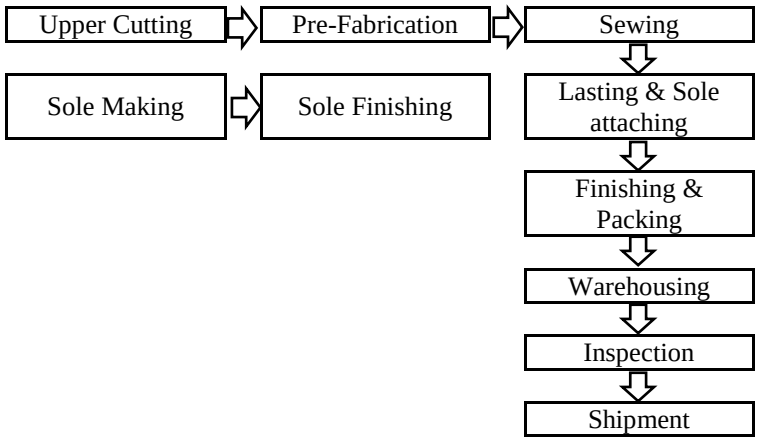

Fig. 2 Flow Chart of Shoe Manufacturing

DMAIC is a control system with a feedback loop that dispels unnecessary steps, often concentrates on new dimensions, and applies technology for consecutive improvement.

Define Phase

The project title, background and reasons for selecting the project, project goal, voice of the customers, project boundary, team members, expected financial benefits and consumer benefits was defined using sigma tools project charter[8]displayed in table 1.

Table -1 Project Charter

Project title:	Six Sigma Concept in Shoe Manufacturing for Quality Improvements
Background and reasons for selecting the project:	Footwear manufacturing process involve in potential sources of errors and problems which may lead to product complaints and rejection.
Project goal:	To reduce errors and improve quality in footwear manufacturing using six sigma concept
Voice of the Customer:	Product's quality
Project Boundary:	Focusing on complete shoe manufacturing process
Team Members:	Production manager, experienced shop-floor Operator and Quality control manager
Expected Financial Benefits:	Considerable cost saving due to defects elimination
Expected Customer Benefits:	Receiving the products with desired quality

Measure Phase

In table 2, data on common defects in footwear manufacturing was collected and evaluated the existing sigma level through calculation of DPMO. The data was measured through pare to chart [9] shown in fig. 3, to select a limited number of tasks that produce potential overall effect.

Table -2 Common defects in Footwear Manufacturing

S. No.	Type of Common Defects	Total Opportunities (pairs/month)	No. of Defects (pairs/month)
1	Half cut / Partial cut	16050	48.15
2	Different marks(pox, ticks, growth)	16050	08.25
3	Direction fail	16050	08.25
4	Needle mark	16050	16.25
5	Toe lasting crooked	16050	80.25
6	Too much wrinkles at toe & heel	16050	80.25
7	Adhesion problems in diff. portion	16050	32.10
8	Seam crooked	16050	80.25
9	Wrong back height	16050	80.25
10	Quarters height up-down	16050	80.25
11	Stitch tearing	16050	72.25
12	Over roughing	16050	32.10
13	Thread burn	16050	08.25
14	Poor sole adhesion	16050	48.15
15	Sole off center	16050	32.10
16	Stain not removable	16050	32.10

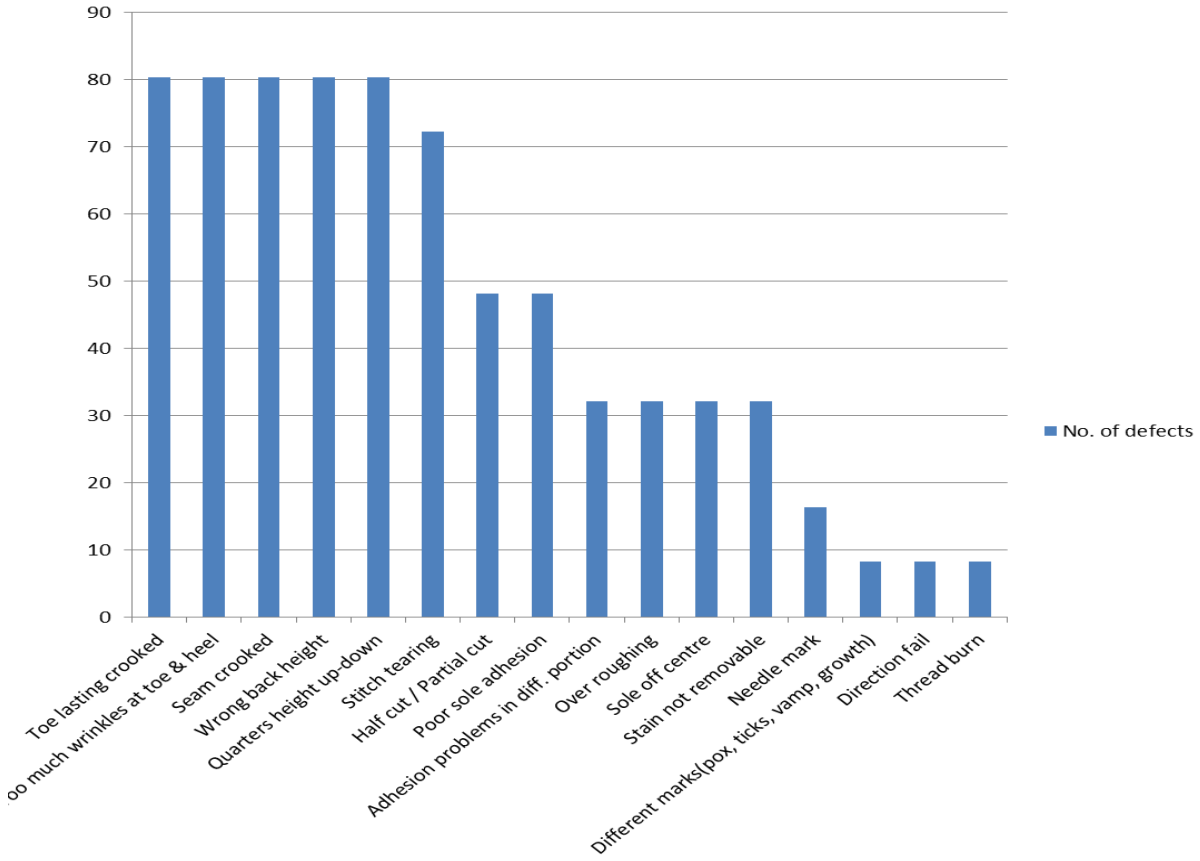

Fig. 3 Pareto Chart of Common Defects

Existing Sigma Level of the company; Calculation of DMPO:

Total defects = 8870

Total units = 192600

$$\textbf{Yields} = \frac{\text{Total units} - \text{Total no. of defects}}{\text{Total units}} \times 100$$

$$= \frac{192600 - 8870}{192600} \times 100 = 95.39\%$$

$$\textbf{DPMO} = \frac{\text{Total no. of defects}}{\text{Total no. of units}} \times 1000000$$

$$= \frac{8870}{192600} \times 1000000 = 46054$$

By using sigma conversion table [3] for 46054 DPMO value denotes sigma level 3.2

Analyze Phase

The causes of defects or failures isolated from pare to chart and their effects, sources of variation and prioritized opportunities for future development was analyzed through fishbone diagram [10]. The diagrams have represented the primary and secondary causes of those defects very organize way in figure4 to figure9.

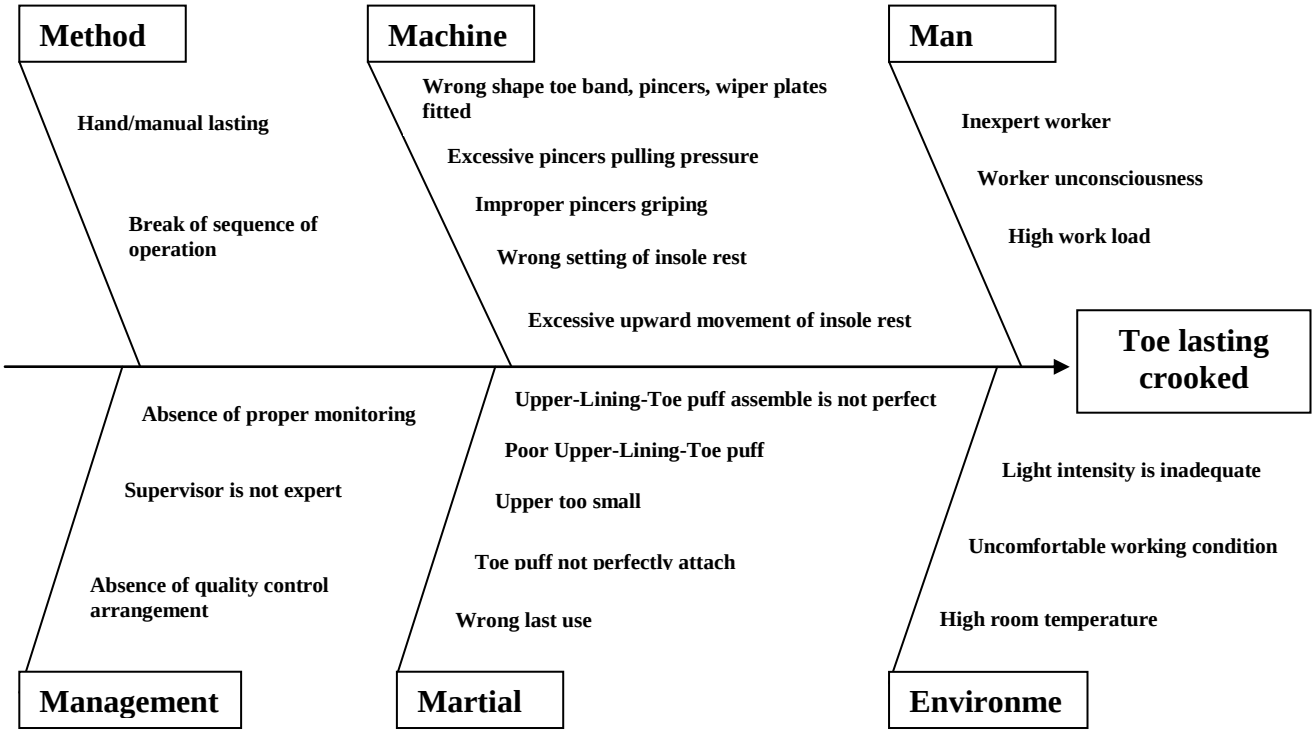

Fig. 4 Cause and effect diagram of toe lasting crooked

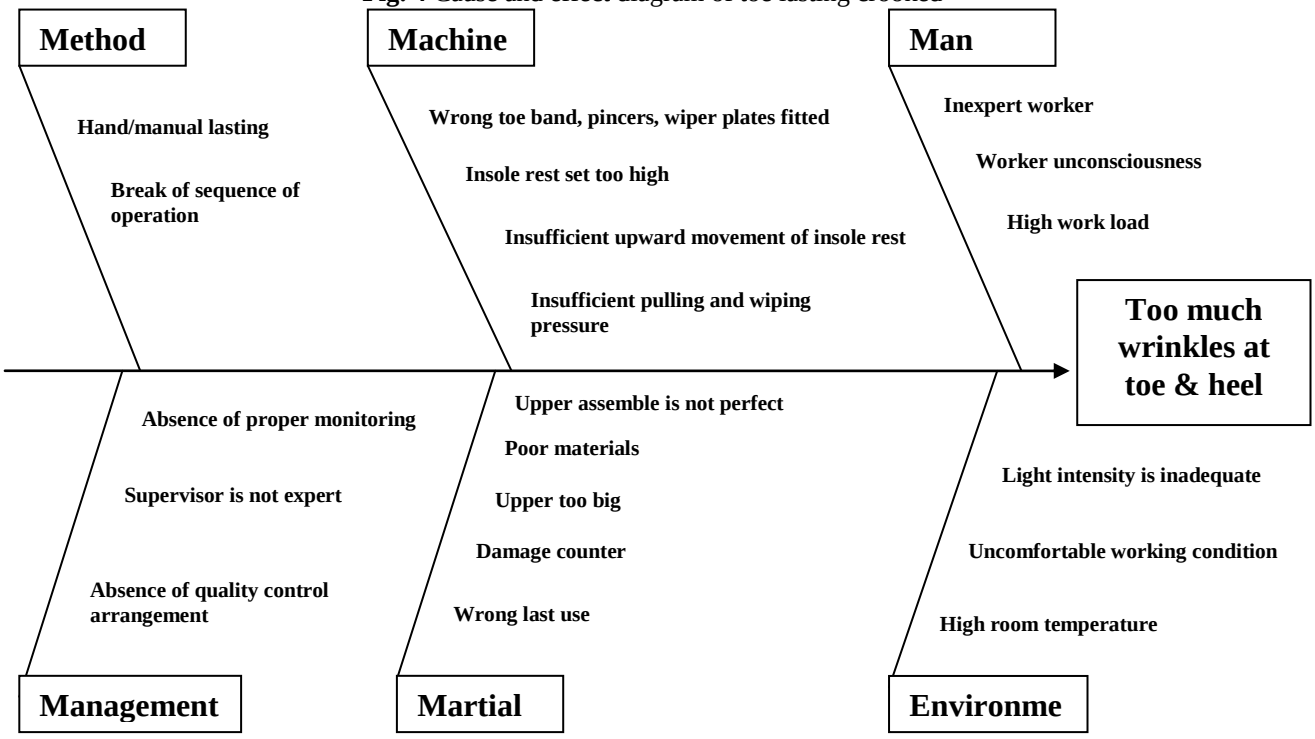

Fig. 5 Cause and effect diagram of too much wrinkles at toe & heel

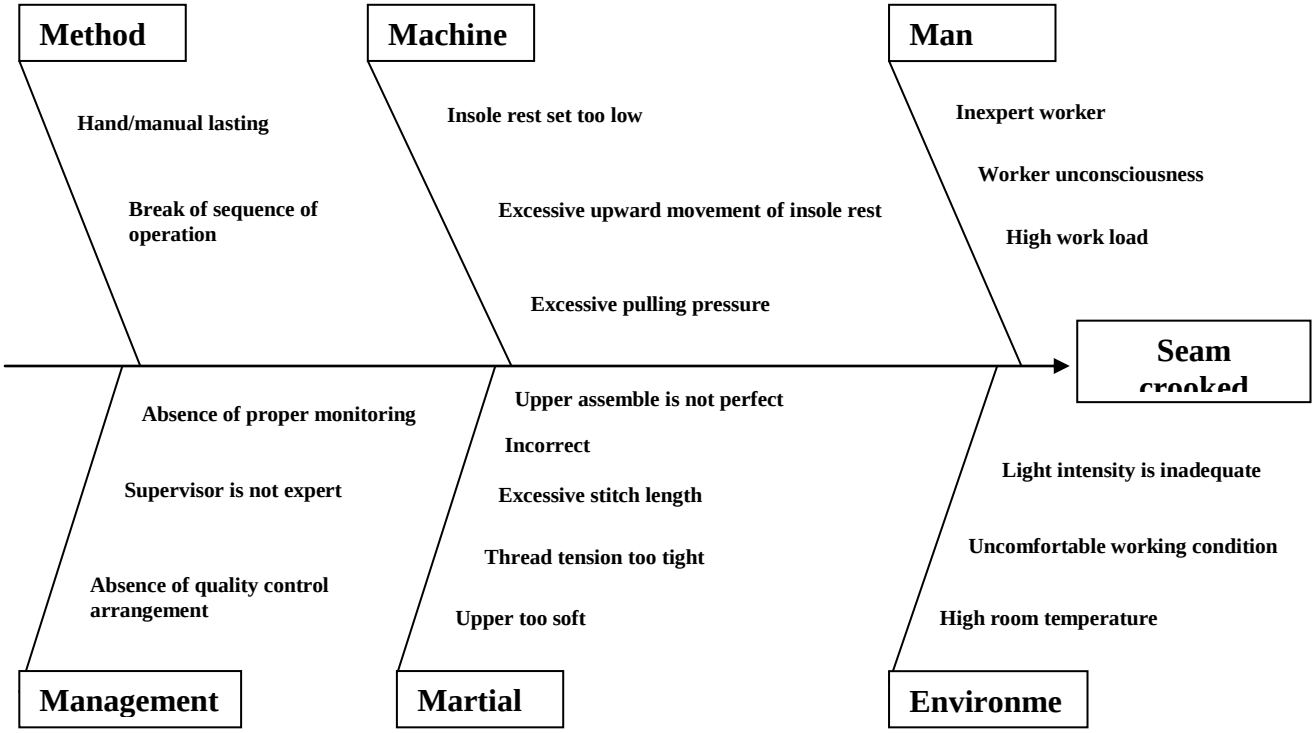

Fig. 6 Cause and effect diagram of Seam Crooked

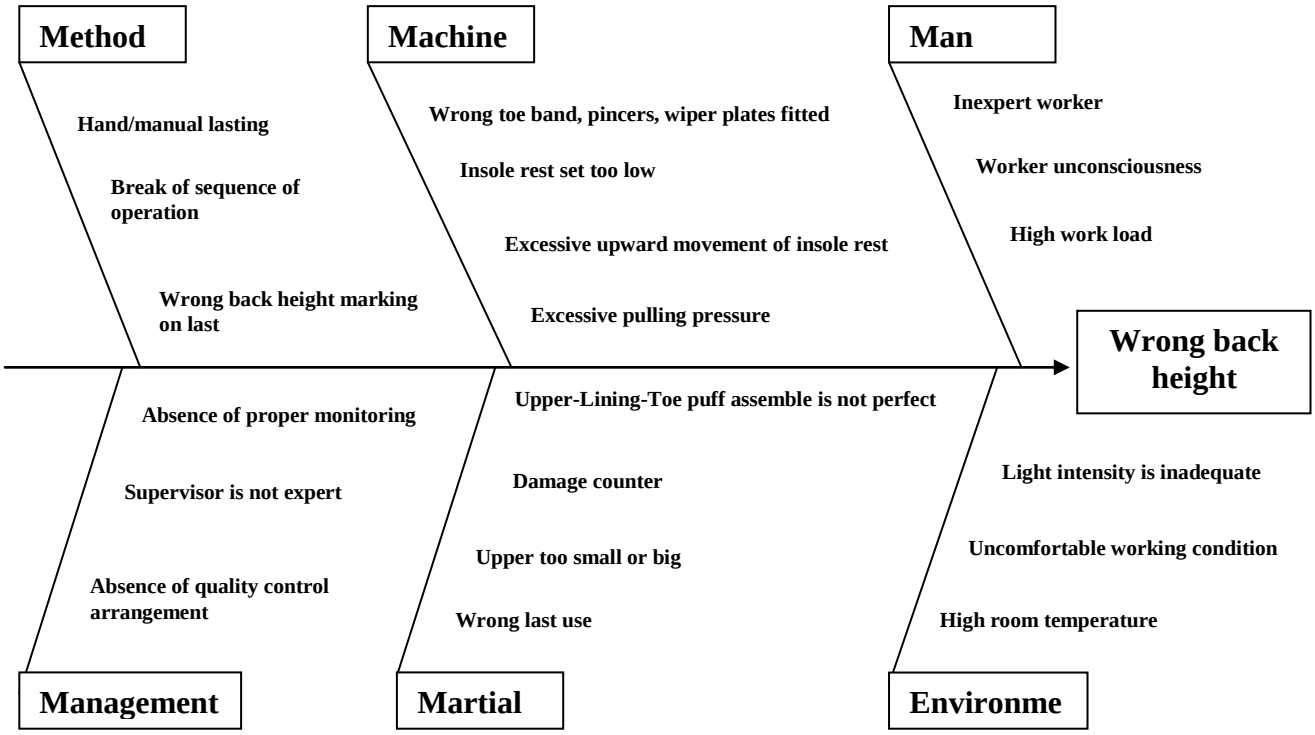

Fig. 7 Cause and effect diagram of wrong back height

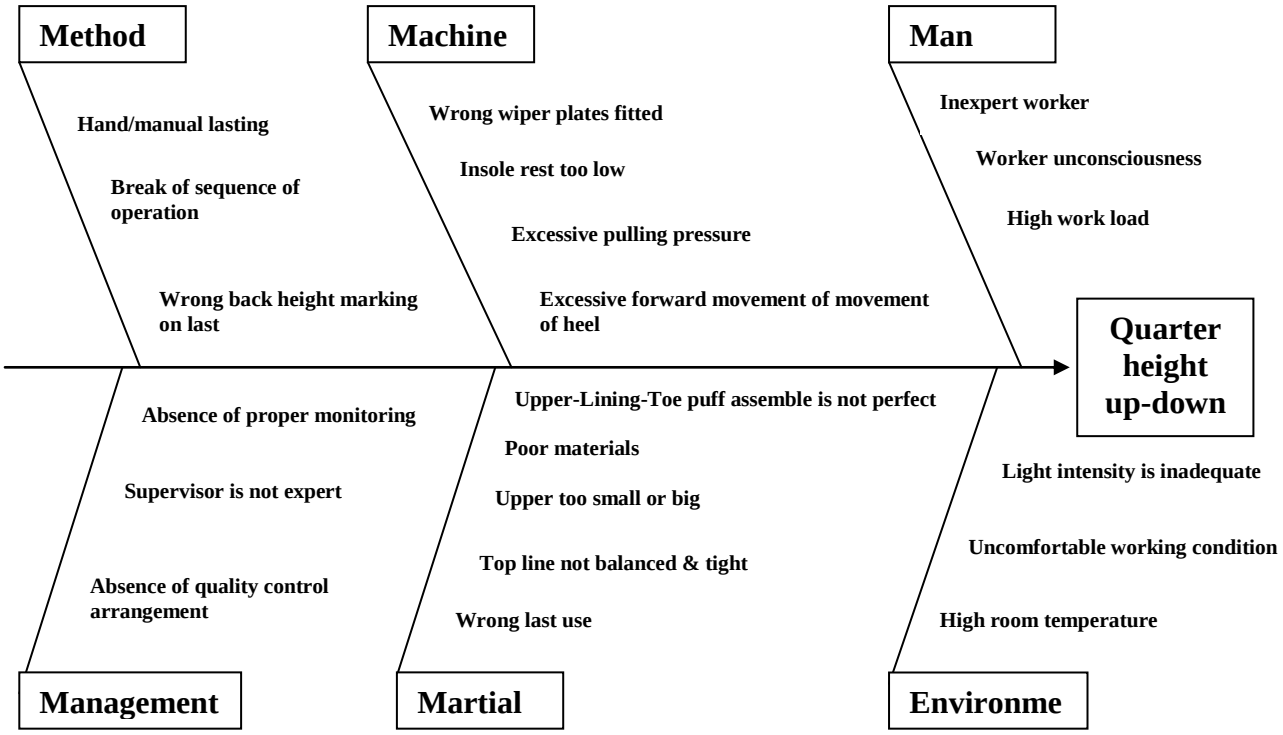

Fig. 8 Cause and effect diagram of quarter height up-down

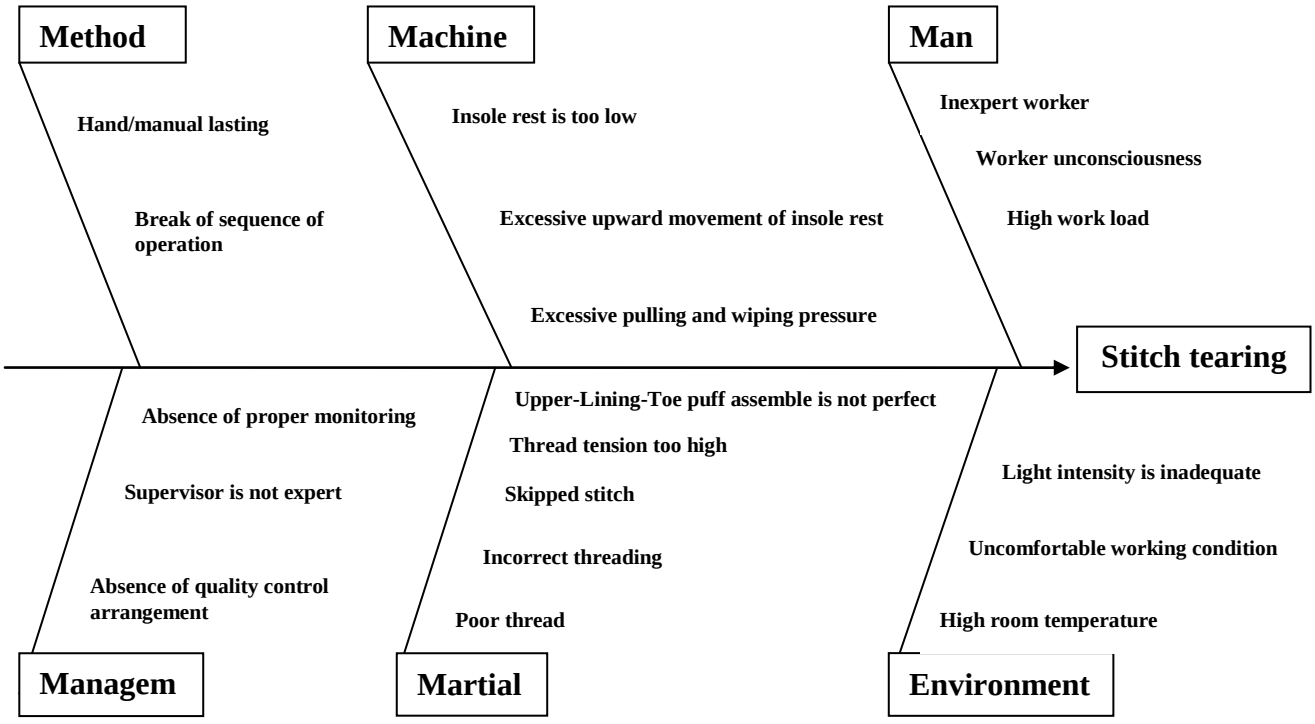

Fig. 9 Cause and effect diagram of stitch tearing

Improve Phase

An improvement charter using 5W1H tools [11] was developed to dispel defects and variations through team members who provide solutions for improvement of the key causes confirmed in the preceding analysis. It is the stage to explore the process to fix, modify, and change the manufacturing setup. Pilot setup can be used before final application of plan to the process. If desired output not found, additional plans can be carried out. The steps of improvement are as displayed in table 4 to table 9.

Table -4 Use of 5W 1H method in improvement of Inexpert Man/Worker/Labor

5W1H	Type	Description
What?	The main purpose	Improvement Inexpert man/worker/labor
Why?	Reason uses	Improve quality of man/worker/labor for quality work and minimize level of defects
Where?	Location	In every department
When?	Sequences	In cutting, sewing, lasting, finishing
Who?	People	Expert trainer, experienced personnel, training agency
How?	Method	Train men/worker/labor for a single work done. It will help them to improve their efficiency for a specific work which will improve quality of work and decrease the rejection level of the production

Table -5 Use of 5W 1H method in improvement of Improper Upper-Lining-Toe puff-Stiffener assemble

5W1H	Type	Description
What?	The main purpose	Improvement of Upper-Lining-Toe puff-Stiffener assemble
Why?	Reason uses	More accurate fitting upper more accurate lasting and quality shoe production
Where?	Location	Joining or Sewing department
When?	Sequences	When cutting and stitching different pattern as per design
Who?	People	Cutter, skiver, adhesive applier, sewer
How?	Method	Set accurate skiving depth, apply adhesive accurately, set stitch method as per design, assembling pattern as per accurate size, make sure lining shorter than upper, check every step of operation

Table -6 Use of 5W 1H method in improvement of Poor upper, lining, toe puff, stiffener materials

5W1H	Type	Description
What?	The main purpose	Improvement of Poor upper, lining, toe puff, stiffener materials
Why?	Reason uses	Poor malarial cause more defects
Where?	Location	Input material department
When?	Sequences	During input material for very first moment of start production
Who?	People	Purchaser, material loading manager
How?	Method	Check material before start production for quality assessment as per design and requirement

Table -7 Use of 5W 1H method in improvement of incorrect threading

5W1H	Type	Description
What?	The main purpose	Improvement of incorrect threading
Why?	Reason uses	More accurate threading for minimize rejection level
Where?	Location	Joining or Sewing department
When?	Sequences	During stitching different pattern as per design
Who?	People	Sewer
How?	Method	Use accurate thread, set accurate stitch length, set accurate stitch tensile force, stitch at stitch line direction, use accurate needle

Table -8 Use of 5W 1H method in improvement of incorrect lasting machine adjustment

5W1H	Type	Description
What?	The main purpose	Improvement of incorrect lasting machine adjustment
Why?	Reason uses	Adjust lasting machine as per material & design for decrease rejection level
Where?	Location	Lasting department
When?	Sequences	During lasting with lasting machine
Who?	People	Lasting machine operator
How?	Method	Test machine before lasting Check toe bands, upper plates, pincers & sole press pad suit the last being used Insole are molded correctly & fit the last Check all pairs after &before roughing Test first 3-5 pairs and observe type of defects occur and adjust lasting machine as per required

Table -9 Use of 5W 1H method in improvement of improper management

5W1H	Type	Description
What?	The main purpose	Improvement of improper management
Why?	Reason uses	Improve management for quality assurance to minimize rejection level
Where?	Location	From material loading to finishing & packaging
When?	Sequences	Before and after starting of any operation
Who?	People	Quality control manager
How?	Method	Set proper quality arrangement, make proper layout of production process, set scope for check quality before & after of any operation

Control Phase

The aim of this phase is to establish the improvement plans from previous analysis through proper monitoring and process control systems [12]. Control charts can be used to monitor the system performance. This stage helps review and updates the setup. This keeps control on all phases discussed above. During implementation of the control phase, it is to be assured that, the suggestions from the team members are implemented and sustained. It needs to construct a proper guideline to ensure this aspect for the supervisors to check whether the operators implement the suggestions. It needs to develop a separate observation booth for the continuous inspection of the shoe after and before start and completion of an operation in every department. Inspectors must prevent the defective shoe from entering into next operation.

RESULTS AND DISCUSSION

A case study has been taken in a reputed shoe industry of Bangladesh. The industry produces approximately 16050 pairs of shoes per month on average. It is functioning under proper administrative structure. Different department of shoe production produces a huge variety of defects or error and variation. In order to eliminate defects and enhance the quality of shoe adopt six sigma approaches. Through Sigma tools it was fixed the ultimate goal of this industry and the perception of the customer about the products. There are about 8870 pairs of shoes rejected among 192600 pairs per year due to defects problem that means percentage of yields 96.89% which denote the existing sigma level 3.2. Therefore to increase the sigma value of processes, most influencing factors need to be identified. Pareto chart was helped to isolate the potential areas of defects that produce the major percentage of failure. According to this chart among the huge variety of defects only toe lasting crooked, too much wrinkles at toe and heel, seam crooked, wrong back height, quarter's height up-down, and stitch tearing covers 64% of total error. The causes of these isolated 64% defects was analysed through fishbone diagram. The man, machine, method, management, material and environment were the primary causes of this problem statement which also disclosed its internal secondary causes in the side bone. After that an improvement plan based on the nature of this problem was developed to eliminate the causes of failure using 5W1H tools where the reason, place of development, sequences, way of problem solving, personnel etc. was fixed. Finally it was suggested a proper controlling and monitoring system that ensured that the suggestions from the team members are implemented and sustained. Six sigma is a control loop system and through this way it is possible to earn the desired six sigma quality.

CONCLUSION

Six sigma is a very popular tool to produce quality products and services by improving the processes and also to achieve customer satisfaction. This study provides a case analysis and demonstrates the novel approach for the application of six sigma technique in a shoe factory for improving the quality and reducing the rejection by dispelling the causes of defects.

From this it can be said that as long as the organization continues embracing six sigma methodology within its continuous improvement culture and applies its concepts and principles to systematically solve quality problems, it is believed that benefits such as cost savings, increase in products' quality and consumer satisfactions will be achieved. Therefore, the article can be helpful for the shoe manufacturers to improve quality in their organizations. To implement six sigma tools in shoe manufacturing, the first and the foremost condition is the quality consciousness mind in the authority of the organization and the categorical commitment and continuous effort by every participant in the shoe production system are essentially required.

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